Interaction and Disorder Effects in Condensed Matter Systems

Claudio Chamon, Boston University, DMR CAREER Award #9876208

Aging is usually thought of a property of biological systems. However, inorganic physical systems can also age, i.e., have properties that depend on the time since the system is quenched below a temperature where the dynamics becomes extremelly slow. We have developed a theoretical framework to understand aging in glassy systems of spins. One of the predictions of the framework is that aging is heterogenous throughtout the spatial extent of the system. These predictions were verified in Monte Carlo computer simulations run at the Boston University supercomputing facility, supported by the NSF-funded MARINER project.

Non-equilibrium effects can also occur in material systems when they are driven periodically. Our group has also studied “quantum pumps” that, when driven periodically, can transfer electronic charge and spin across systems of reduced dimensionality, such as quantum dots or quantum wires. We have shown that when the pump is run adiabatically, only integer multiples of the electron charge or spin can be transferred across an interacting system. Because there is no simple analog for a battery for spin transport, the quantum spin pump can be of particular interest for spintronic devices.

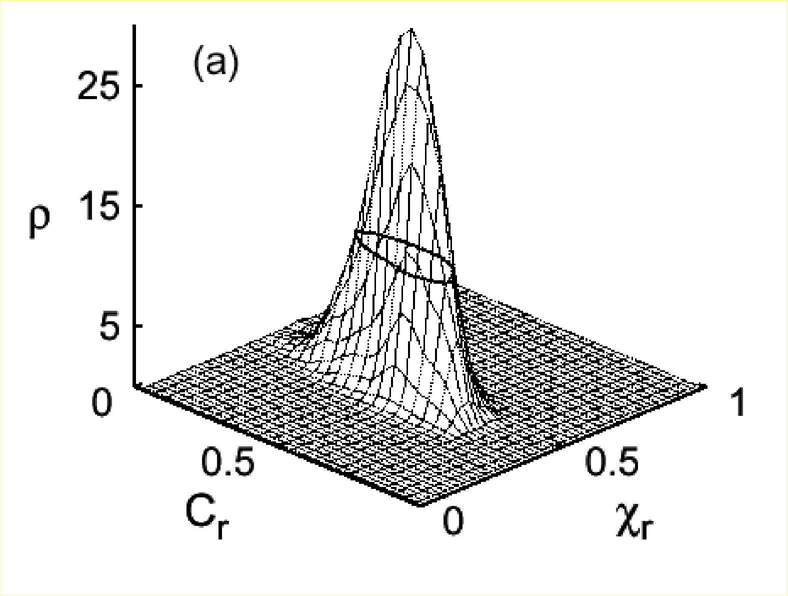

Figure 1. Joint propability distribution for spin-spin correlations and susceptibilities for a system of 64x64x64 spins with +/- J nearest neighbor couplings. The temperature T = 0.72 Tc, and the time since the quench is 10000 MCS. Points within the contour account for 2/3 of the total probability. The broad distribution of spin-spin correlations signals a heterogenous aging process. The large aspect ratio of the distribution is consistent with a well defined local relation between correlation and susceptibility, consistent with an off-equilibrium fluctuation dissipation relation.

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Educational:

Graduate students:
Claudio Castelnovo, Boston University
Prashant Sharma, Boston University
Dmitry Green, Yale University (co-advised)
Malcolm Kennett, Princeton University (co-advised)

Post-doctoral associate:
Horacio Castillo, Boston University

Future positions of “graduates” of Chamon’s group:
Prashant Sharma, postdoc at Cornell Univ.
Malcolm Kennett, postdoc at Cambridge Univ.
Dmitry Green, associate at McKinsey & Co.
Horacio Castillo, Assistant Professor at Ohio Univ.

Collaborators in the USA and abroad:
Leticia F. Cugliandolo, ENS, Paris, France
Andreas W. W. Ludwig, UCSB
Eduardo R. Mucciolo, PUC, Brazil
Christopher Mudry, PSI, Switzerland
Chetan Nayak, UCLA
Charles M. Marcus, Harvard Univ.
T. Senthil, MIT

Brief summary of outreach activities:
- Judge, Chelsea High School Science Fair
- Judge, Boston University Science Day

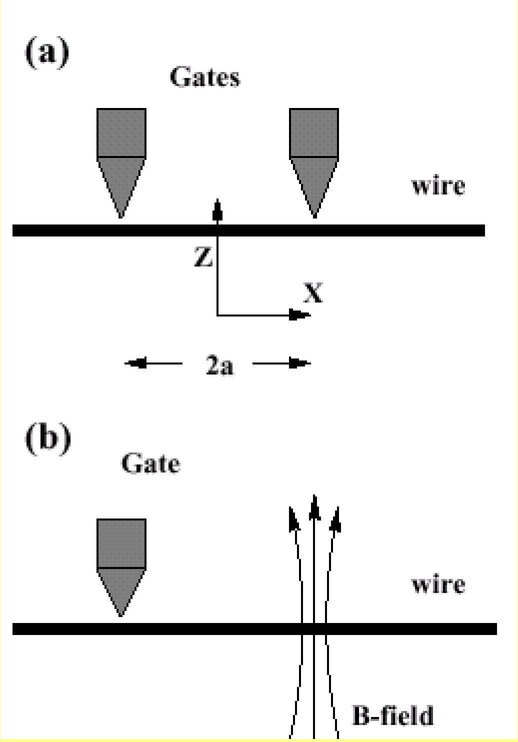

Figure 2. (a) Geometry for a charge pump in a quantum wire. Two gates placed a distance 2a apart are biased with ac voltages of the same frequency, ω, and relative phase φ. (b). Geometry for a spin pump. In addition to a gate as in (a), a inhomogeneous magnetic field points in the z-direction near x = a, and oscillates with frequency ω and a shifted phase φ.